A DAY AT A SUGAR-REFINERY.

[Interior of a Sugar-Refinery.]

If it were allowable to personify the east and west ends of London, we might consider them as strangers who have occasionally heard of each other's existence, but who, from the wide interval between them, have had little mutual acquaintance. The dweller at the 'court end' of the town may, perhaps, have heard of 'Aldgate Pump,' as a spot remotely east, beyond the regions of the Bank, the Exchange, and the Mansion-House; and may, without the aid of a map, be in some doubt as to what exists still farther eastward. But he who would form an adequate idea of the metropolis in all its length and breadth, must be prepared to hear of a vast population,—a very world of human beings,—beyond the point to which we allude.

It is to this eastern district, and to one particular part of it, that we beg to direct the reader's attention in the present article. Most persons have heard of the occupation of a sugar-refiner,—often, though erroneously, termed sugar-baker,—that is, one who prepares the white conical lumps or loaves of crystallized sugar familiarly known as 'loaf-sugar.' Now, the buildings or 'refineries' in which this operation is carried on are not only situated in the east of London, but most of them are congregated within a circle of half a mile radius immediately eastward of Aldgate. Those who would seek for a reason why so many members of one trade or manufacture settle near each other, may be reminded that Oriental bazaars exemplify this custom to a remarkable extent, and that the object is principally to afford facilities to purchasers. At Constantinople, Bagdad, and other Eastern cities, each of the principal trades has its own bazaar,—one for jewellery, one for silks, one for spices, and so forth; and purchasers know at once what part of the city to visit when any commodity is required. In London, the admixture of trades and professions in most trading streets is now such, that the bazaar method is little observable; but still, whoever notices the assemblage of sugar-refiners in the neighbourhood of Goodman's Fields, the wool-combers in Bermondsey Street, the coach-makers in and near Long Acre, the watch-makers in Clerkenwell, the statuaries in the Paddington Road, and many similar instances, will not fail to observe indications of this custom, and to attribute it to some sufficient motive. Proximity to docks and warehouses furnishes a principal motive in the first-mentioned instance. Whether the sugar-refineries have, ever since their introduction into England, been located in this district, we do not exactly know, but should deem it very probable. Stow, in the following remark, does not make mention of any particular part of London:—"About the year 1544 refining of sugar was first used in England. Then there were but two sugar-houses; and their profit was but little, by reason there were so many sugar-bakers in Antwerp, and sugar came thence better and cheaper than it could be afforded at London. And for the space of twenty years together these two sugar-houses served the whole realm, both to the commendation and profit of them that undertook the same."

Sugar-refineries have certain peculiarities in their external appearance, whereby they are distinguishable

from most other factories; they are very lofty, consist of an unusual number of floors or stories, and are lighted by rather small windows. In the sugar-refinery of Messrs. Fairrie, which we have recently visited, these peculiarities are very observable. In making the circuit of the buildings we reckoned nearly two hundred windows, most of them small, and some at such a height as to have seven floors or stories between them and the ground. The interior, too, has something peculiar in its appearance, arising from the shallowness of the rooms compared with their great extent; these rooms are very numerous, nearly square, and no higher than is absolutely necessary, since the chief desideratum in a sugar-refinery is a large extent of flooring. The greater part of this building is formed of iron, brick, and stone; a very necessary precaution against fire, on account of the inflammable nature of the substance prepared therein.

Most readers are probably aware, that 'lump' or 'loaf' sugar,—a holiday luxury to the middle classes, and, hitherto, an unattainable one to the humble,—is prepared from common brown sugar by a refining process, and that this process is conducted in the buildings to which we have alluded. In describing the mode of operation, we shall not find it necessary to trace the history of sugar in its previous states; but still a few remarks thereon will aid the object in view, by showing the successive conditions or forms in which the sugar is presented.

In our fourth number will be found a representation of the West Indian sugar-cane, from which the supply of sugar is obtained. "A field of such canes," says Mr. Beckford, "when standing in the month of November, when it is in arrow or full blossom, is one of the most beautiful productions that the pen or pencil can possibly describe. It commonly rises from three to eight feet or more in height, a difference of growth that very strongly marks the difference of soil or the varieties of culture. It is, when ripe, of a bright and golden-yellow; and where obvious to the sun, is in most parts very beautifully streaked with red. The top is of a darkish-green; but the more dry it becomes, from either an excess of ripeness or a continuance of drought, it assumes a russet-yellow colour, with long and narrow leaves depending; from the centre of which shoots up an arrow, like a silver wand, from two to six feet in height, and from the summit of which grows out a plume of white feathers, which are delicately fringed with lilac dye, and indeed is, in its appearance, not much unlike the tuft that adorns this particular and elegant tree." Such is the external appearance of the plant yielding the sugar-juice; and in the article to which we refer above, will be found a brief account of the mode in which the canes are cut and crushed, and of the subsequent transformation of the juice thence obtained into the form of moist or brown sugar, until it is finally packed in hogsheads and exported. It is first a juice expressed from the cane; then a kind of syrup, from which impurities have been removed; and lastly, a brown granulated substance, from which a considerable portion of molasses, or uncrystallizable sugar, has been removed.

The ponderous sugar-hogsheads which we notice at the shops of the retail grocers contain moist sugar somewhat resembling in quality that which is imported by the refiner, but with a finer and softer grain. This sugar, as every housewife familiar with the qualities of 'sevenpenny' or 'eightpenny moist' is aware, has various shades of brown colour, according to the quality; and the principal cause of this colour is, that a quantity of black molasses, or treacle, which formed part of the original cane-juice, is still mixed up with the crystallizable parts of the sugar,—not having been wholly removed by the processes to which the cane-juice is subjected before importation. The particles of sugar in their pure state are white; and to present them in this white crystalline form is the object of the sugar-refiner, who adopts means for expelling the molasses, and also certain impurities which are incorporated with the brown or Muscovado sugar as imported in the hogsheads.

It seems probable that the art of refining sugar was first introduced into Europe by the Venetians, and was practised in Venice some time before it was adopted in any other European country. The foul and black sugar brought from Egypt, at the end of the thirteenth century, was the first material upon which the art of the refiner was employed. The Venetians, in their first attempts, converted the dark moist sugar into sugar-candy; but they soon sought to obtain refined or crystallized sugar by a quicker and more profitable process; which they at length effected by the use of conical moulds, such as have ever since been used. From Venice the art passed into various European countries; and since America has been so fertile in the production of sugar, refineries have increased to a considerable extent in England and other countries.

Let us suppose, then, that a hogshead of moist sugar, imported from abroad, is brought to a refinery, and let us follow it through the routine of processes till it assumes the form of a conical lump of white sugar. This will enable us to describe the uses of the various buildings and rooms forming a large sugar-refinery; taking as our guide that of Messrs. Fairrie, Brothers, and Co., situated nearly behind Whitechapel Church, and which, through the liberality of the proprietors, we have been enabled to inspect.

This refinery consists mainly of two ranges of buildings, in the eastern of which the earlier and in the western the later processes are conducted. The hogsheads of sugar, having been brought in waggons from the docks to the east side of the refinery, are hauled up by a crane, and drawn in at an open door to a large square room. This was the first part of the building which we visited, and a busy scene it presented; here, was a hogshead of sugar, suspended from the crane, and just on the point of being drawn into the warehouse; there, was another hogshead, deposited on a low iron carriage, and being wheeled farther inwards; near it was a third, being weighed,—a process requiring tackle of no slight kind, since the hogsheads, when filled, vary from four to eighteen cwts. each; farther on was a man knocking out the head of a hogshead, and a party of others emptying the contents on a boarded floor; while other hogsheads, some empty and others full, were lying around in various directions. Our frontispiece represents the appearance of these objects

The sugar, when about to be operated on, is transferred from the hogsheads to a wooden floor, from whence it is shovelled into large circular vessels called 'blow-up cisterns.' If we gave a literal acceptation to technical terms, we should sometimes smile, and at other times feel a little alarm: in the present case it appears that the name is given in allusion to the mode in which steam is admitted to the contents of the vessels. The cisterns are six or seven feet in diameter, and about five in height; and the purpose for which they are employed is to dissolve the sugar preparatory to the removal of earthy and other impurities with which it is contaminated. The reader must bear in mind that notwithstanding the purifying processes whereby cane-juice is converted into brown sugar, there are still three kinds of substances which require to be removed from this sugar before the white crystalline state can be obtained, viz., earthy and other impurities, colouring matter, and molasses; and that very distinct processes are resorted to in order to effect

the removal. To remove the impurities is the first object. The sugar is, as before stated, thrown into the 'blow-up cistern;' and water is admitted to it from a cistern at the top of the house, which supplies every part of the establishment, and which is, in its turn, supplied from a well nearly two hundred feet deep, worked by a steam-engine. Into the cistern containing the sugar and water is pumped a small quantity of lime-water. A steam-pipe, in communication with a boiler at the east side of the building, is enclosed within the 'blow-up cistern;' and apertures being opened, steam is forced or 'blown' by its own pressure into the solution, by which the latter becomes heated in a very short space of time. This is one of the many instances in modern manufactures illustrative of the advantages derived from the use of steam as a heating agent. The water in the 'blow-up cistern,' being heated by the steam, dissolves the sugar, aided by constant stirring by means of long poles or oars. The lime-water, which aids in this process, is brought from vessels situated in the eastern part of the premises: they are casks broader at the bottom than the top; and the lime being dissolved in water and stirred till a milk-like fluid is produced, the lime-water is pumped from them as wanted.

This part of the process is one in which great improvements have been made of late years: indeed the same, to a certain extent, may be said of nearly all departments of the refining business. Under the old mode of proceeding, the sugar was dissolved in lime-water over an open fire, whereby it was subjected to a variable temperature injurious to the quality of the sugar; the clarification was effected by the admixture of a large quantity of bullock's blood, and a scum several inches in thickness was allowed to collect on the surface of the vessel containing the sugar, and was thence removed by a broad skimmer. As an illustration of the effect of the albuminous refining substance, *i.e.* the blood, we may refer to the action of hot water on the white of an egg, which is almost pure albumen; the white coagulates, or becomes solid, in two or three minutes. If any liquid containing albumen be mixed in another liquid and heated, the albumen, in the act of solidifying, collects together in a sort of film, and in so doing appears to entangle most of the solid impurities floating about in the liquid, removing them from the liquid generally. This having been repeated two or three times, the solution of sugar was allowed to flow through a wooden channel into an oblong basket covered with a blanket, through which it filtered into a cistern below, carrying a considerable portion of impurity with it. But in the process which we witnessed, the desired effect is produced in a much more efficacious manner; for the temperature of the solution is not greater than that of boiling water, and the offensive clarifying ingredient is almost entirely dispensed with, the process of clarification, or the removal of impurities, being principally effected in the next process. The saccharine solution,—called, in the language of the refinery, 'liquor,'—is, in this case, not skimmed at all; but at a certain stage in the operation, it is allowed to flow from the 'blow-up cistern' into a range of filtering-vessels in a room beneath; into which filters it enters as a thick, opaque, blackish liquid, and leaves them in a beautifully transparent state, though coloured of a reddish hue. The arrangement of these filters is exceedingly ingenious. Several cast-iron vessels about six feet high, each contain sixty cloth tubes, about three inches in diameter, attached to short metallic tubes which are screwed to circular holes in the upper part of the vessel, and hanging vertically downwards. Each tube contains a large bag, made of a close kind of cotton cloth, and coiled up so as to make the whole a compact mass of cloth; and the bags being each two feet wide and six feet long, it is easy to calculate that there are nearly fifteen hundred square feet of cloth comprised in each filtering-vessel. The 'liquor,' then, flows from the 'blow-up cisterns' into a shallow vessel to which these tubes are attached, and thence through the bags contained in the tubes. The bags being closed at the bottom, no outlet exists for the liquid except through the meshes or interstices of the cloth; and as the cloth forming each bag is doubled and re-doubled in its tube, the liquid finds its way between the plies or folds of the cloth, and finally exudes in a transparent state. The whole of the impurities, with the exception of a little colouring matter, are retained by the bags and tubes, while the saccharine liquor passes through.

It must be evident that the impurities left in the bags would soon clog the meshes if not removed. At intervals, therefore, the tubes are unscrewed, and taken out to a washing-yard, where the bags are drawn out, the impurities removed, and bags and tubes thoroughly washed. These impurities still contain a small portion of saccharine matter, which is subsequently extracted from them by boiling and other processes; and the spent residue is finally sold as manure, for which it possesses valuable qualities.

The next point in our visit was to the rooms in which the process of decoloration is carried on. The reader will bear in mind that the state to which we have traced the sugar in its progress is that of a transparent liquid having a reddish tinge. To remove this tinge, without interfering with the transparency of the liquid, is the next object of attention, and charcoal is the agent which modern inquiry has shown to be best fitted for this purpose. It has been long known that common wood charcoal possesses the property of removing, more or less, the odour proceeding from animal and vegetable substances in a state of decomposition; but it was also discovered by the German chemist Lowitz, that the same substance will remove the colour from common vinegar and several other liquids: a fact which soon afterwards led to the employment of charcoal in the clarification of various pharmaceutical preparations, and as an auxiliary in the refining of sugar. About thirty years ago, M. Figuire, of Montpellier, ascertained the additional important fact, that charcoal obtained from animal substances is not only equally efficacious when used in considerably smaller proportion than vegetable charcoal, but that it is capable of decolouring many liquids on which the latter has no sensible effects whatever. The sugar-refiners immediately availed themselves of the knowledge of this fact; and since that time many different modes have been adopted of employing animal charcoal in refining.

What is meant by animal charcoal is the earthy and carbonaceous portions of *bones* obtained by burning them in retorts; certain other ingredients in the bone are driven off by the heat, leaving an intimate mixture of phosphate and carbonate of lime with carbon, which then obtains the name of animal charcoal. It is not well known in what manner charcoal acts on the colouring particles of bodies; but Mr. Aikin, in one of his Lectures, makes the following remarks on the comparative action of vegetable and animal charcoal: "It is certain that the more finely divided any given weight of charcoal is, the more powerful is its decolouring effect; and thus the inferiority of those kinds of charcoal that break with a glossy fracture, when compared with those of a dull fracture, is accounted for: the particles of the former being assumed to be nearly solid, and those of the latter to be porous, or, in other words, more minutely divided. In bone or animal charcoal the carbonaceous particles are separated from

each other by the large quantity of earth with which they are mixed; and hence the superiority of this to vegetable charcoal resolves itself into a case of very minute division." These points, however, are not yet settled.

We return, then, to the operations on the sugar, which we had traced through the filtering-bags. All the liquor, as it leaves the filters, flows through pipes into other parts of the building occupied by charcoal-cisterns, each of which is a square vessel, four or five feet in height, and provided with a double bottom, the upper one being perforated with small holes. On this perforated bottom a piece of cloth is laid, and on the cloth a layer of powdered animal charcoal, or 'bone-black,' nearly three feet in thickness. The saccharine liquor flows on the surface of this charcoal bed, through which it slowly finds its way, percolating to the bottom, then through the meshes of the cloth, and lastly through the perforations into the vacant space beneath. The effect of this filtration is very striking; for the liquor, which, though transparent, is of a reddish colour when it flows into these cisterns, leaves them in a state of colourless transparency almost equal to that of pure water. Such a complete decoloration is the best proof of the success of the modern improvements in this branch of manufacture. The cloth bags, and the arrangements by which the liquor is made to flow through them, remove all the opaque impurities; while the charcoal and the apparatus of which it forms a part, remove the colouring matters from the filtered liquor.

In the eastern part of the premises is situated a retort-house, supplied with furnaces, retorts, and various subsidiary arrangements. These, whose use might to a stranger appear rather inexplicable in a sugar-refinery, exemplify one of the most curious and valuable properties in the charcoal employed. When the process of decolouring the sugar has rendered the charcoal impure, water is poured through the mass in the cisterns, until all the soluble part of the saccharine impurities is removed; after which the charcoal is removed from the square cisterns, carried to the retort-house, put into iron retorts—of which there are a large number, each eight or ten feet long, and re-burned. The arrangements for this purpose are on a considerable scale, and very complete; and the process is so conducted that the charcoal leaves the retorts in a state as fit for use as when it was first made; all the impurities having been burned away, without any deterioration in the decolouring qualities of the charcoal. Thus the same portions of charcoal may be used over and over again. This decolouring process was first employed in this country on a large scale by Messrs. Fairrie; who likewise adopted the mode here described of recovering the power of animal charcoal, several years before it became publicly known.

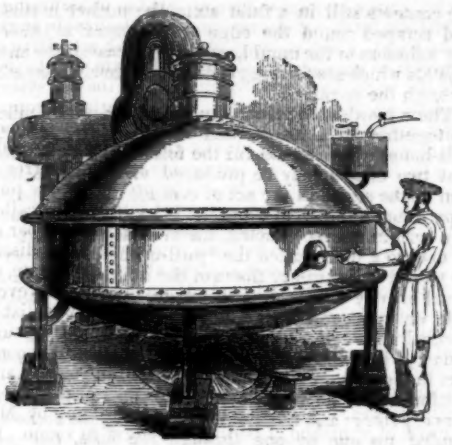
Every one knows that 'loaf' sugar, as well as 'moist,' possesses different degrees of whiteness and clearness of appearance. The mode in which these different qualities arise we shall presently state; but we may here remark, that it is only the finest qualities which present the pure and colourless appearance alluded to above, after passing through the charcoal. The inferior kinds retain a slight tinge of colour.

We next visited that part of the building in which the most important of all the operations is carried on, viz. the boiling. If we were to attempt a description of all the inventions and contrivances which have been brought to bear on this process, it would not only absorb all our remaining space, but would involve scientific details unsuited to our purpose: it must suffice to show how the method usually adopted at the present day differs from the old one, now almost obsolete.

The 'liquor' consists of sugar capable of assuming a crystalline form,—molasses, or uncrystallizable sugar,—and water; and the object of the boiling is to drive off a portion of the water in the form of steam, and to prepare the sugar for crystallizing. Under the old system the saccharine liquor was poured into a large copper vessel called a 'pan,' and there boiled over an open fire, at a temperature gradually rising to 230° or 250°, until the evaporation had caused it to assume a degree of viscidity known by experience to be proper for the purpose. From the pan it was emptied into vessels called 'coolers,' where it was beaten violently with an oar or staff, by the action of which the sugar was so far disentangled from the molasses as to be able to granulate, or become partially crystallized. It was found, however, that, independent of other evils, the sugar was liable in that process to be injured by the high temperature at which it boiled; for there is a tendency to decomposition even at the temperature of boiling-water; and at a still greater heat the tendency is increased. These circumstances led to the happy suggestion, by Mr. Howard, of a method of boiling the sugar in vacuo. In the common operations with which we are familiar, boiling water is always nearly of one temperature, because it is exposed to a tolerably uniform atmospheric pressure; but if this pressure could be removed by the action of the air-pump, or some other means, boiling would take place at a temperature so low that the hand could bear it with impunity. So likewise in the case of sugar-liquor: if the pressure of the atmosphere could be removed, the process of boiling, which is nothing more than a very rapid evaporation, would take place at so low a temperature that the sugar would not be injured by it, viz. from 130° to 150°, that is, one hundred degrees lower than under the atmospheric pressure. Such were Mr. Howard's views; and few scientific suggestions have ever been attended with more complete success. Nearly all the principal sugar-refiners now boil sugar in vacuo, more or less perfect; each one adopting a form of apparatus or a routine of processes best suited to the circumstances under which he conducts his business. We shall presently make a few further remarks on the introduction of this plan; but it will be desirable first to trace the sugar through the boiling process.

The pans which we saw at Messrs. Fairrie's refinery are circular, domed, copper vessels, from six to seven feet in diameter, and nearly the same in height. No fire is visible beneath them; indeed throughout the refinery we saw scarcely a symptom of a fire: whether the purpose be to heat a vessel of water, to boil the sugar in vacuo, to heat a stoving-room, or to warm the buildings generally, the heating power is supplied by steam, which traverses almost every part of the premises in pipes. Each pan is completely covered in, air-tight; but there are many channels of communication with other vessels: one admitting liquid sugar to the pan, another furnishing a channel through which it may flow out; a third admitting steam for boiling the sugar; and a fourth serving as an exit for the air originally contained in the pan, and also for the steam evaporated from the sugar. Various pieces of mechanism are attached to each pan, whereby the temperature of the liquid, the quantity contained in the pan, &c., may be tested; but these need not be further particularized. The external appearance of each pan, and the appendages belonging to it, are seen in the subjoined cut.

The process, then, is briefly this:—the liquid sugar, after percolating through the charcoal, and being collected in a cistern several feet below the pans, is placed in communication with them by an ascending pipe; and the air being withdrawn from within each pan by means of an air-pump, the liquid sugar ascends the



pipe into the vacuum by atmospheric pressure from without, on the same principle as the water ascends in a common pump. Steam is then admitted to a vacant space below the sugar in the pan, and also through pipes traversing the interior; and by these means the sugar is brought to a boiling state while comparatively at a low temperature, on account of the tolerably perfect vacuum existing above the surface of the liquor in the pan. As the evaporation proceeds, the vapour flows through a large iron pipe into an open court, where a cistern of cold water condenses it as fast as it is formed, and thus maintains a vacuum within the boiler. The sugar by this evaporation thickens and becomes partially granulated or crystallized; and to ascertain how far this process has extended, a most ingenious instrument, called a 'proof-rod,' is used, by which a small quantity of sugar may be taken out without disturbing the vacuum in the pan. This 'proof-rod' may be regarded as a key which unlocks a little valve in the body of the pan, draws out a sample of sugar, and locks the valve again. A hollow tube is fixed in the pan, with the outer end exposed to the atmosphere, but the inner end immersed in the liquid sugar. This inner end is constructed with a socket and plug, like the key of an ordinary liquor-cock, with two apertures through which, when open, liquor may flow. The 'proof-rod' is a straight brass rod with a handle, having a key at the farther end, which, on being introduced into the tube and turned round, unlocks the socket and plug in the tube, and allows the liquid sugar to flow through the apertures of the socket and plug into a recess at the bottom of the key. The proof-rod being again turned, locks up the apertures in the tube, and on being withdrawn brings with it a small sample of liquid sugar.

The attendant 'boiler' then tests the state of the sugar, by taking a little between the thumb and finger, and trying what degree of tenacity and granulation it has acquired. If the result is not satisfactory, the boiling is continued for some time longer; but if satisfactory,—and this is a matter that requires constant experience to determine,—a valve at the bottom of the pan is opened, and the sugar flows through a pipe into a room beneath, where vessels are placed for its reception. The sugar, as it flows through, appears to be much altered, for it is now a mass of crystals enveloped in a dark-coloured syrup. All the pans are nearly alike in their mode of arrangement, and the reader will understand that the purpose to which they are applied is to drive off, in the form of vapour, so much of the water which has been mixed with the sugar as to enable the latter to crystallize. The steam employed as the heating agent is brought from a large boiler in the eastern part of the premises, which similarly supplies many other departments of the building.

One of the most marked points of difference between the old and the recent methods of boiling is this:—that under the old system, the temperature at which the concentration was carried on was so high that crystallization could not take place till a subsequent cooling had been effected; whereas under the system introduced by Mr. Howard, the crystallization actually takes place, to a considerable extent, in the boiler itself. It was nearly thirty years ago that Mr. Howard took out his first patent respecting sugar-refining; but, like many other improvements, it made its way slowly into favour among manufacturers. The experiments on which he grounded his plan were made with a small table apparatus; and when, through an arrangement with a refiner in a large way of business, the method was put into practical operation, it was found to produce indifferent sugar, with weak, soft, and small crystals. After many attempts, however, all the practical difficulties were overcome; pure, large, and bright crystals of sugar were produced by the new method; and many refiners, both in London and elsewhere, adopted the patent process, for the use of which they paid a stipulated annual premium. There were some years in which the premiums thus paid by several refiners collectively amounted to more than forty thousand pounds.

We resume our description. After having witnessed the operations and apparatus connected with the boiling, we next followed the progress of the sugar to a room on the lower floor of the building, containing vessels called 'heaters,' into which the sugar flows

from the pans. It is a curious circumstance, that under the old system the corresponding vessels were termed 'coolers,' as being at a much lower temperature than that at which the sugar was boiled in the pans; but they are now called by an opposite name, because the sugar is here raised to a temperature of about 180°, having previously been boiled at 135° or 140°. While being raised to this higher temperature, the sugar is kept constantly stirred; and at a certain point in the process it has acquired a state which renders further heating unnecessary. The object of this process is not so much to crystallize the sugar (for that has already been effected in the pan), as to impart to it a consistence which facilitates the subsequent processes, and gives to the loaf of sugar a firmer texture.

Recalling to mind what has been already stated, it

will be seen that the sugar has been successively deprived of its solid impurities, its colouring-matter, and of some of the water which had been mixed with it; but the molasses, or uncrystallizable parts of the sugar, still remain. To separate these, therefore, is the object of the next few processes, technically termed 'filling-out,' 'washing,' and 'netting.'

The 'fill-house,' the part of the refinery to which our visit next led us, presented a singular appearance. It is a very large square room, on the basement story, paved with stone, and having brick walls and ceiling. A considerable portion of the floor was covered with iron conical moulds, about two feet in height, and six inches in diameter at the largest part; each one placed with its apex downwards, and upheld by those with which it was surrounded. Hundreds, and probably thousands, of these moulds were thus ranged in close rank and file; some filled with sugar from the 'heaters,' others in the act of being filled, and the rest empty, waiting to be filled at a subsequent part of the day's operations. These were the moulds which give the well-known 'sugar-loaf' shape to the masses of white sugar seen at the shops of the grocers. Among the improvements which the business of sugar-refining has undergone, is the substitution of iron moulds for those made of clay; the latter used to be universally employed, but the former possess many advantages, and have almost superseded them.

A busy scene presented itself in the 'fill-nouse.' A number of men, each stripped from the waist upwards, were engaged in filling the moulds with liquid sugar from the 'heaters,' each man carrying before him a large copper basin shaped somewhat like a coal-scoop, and capable of holding above a hundredweight of melted sugar. The men went to the 'heaters' filled their scoops with the hot viscid sugar, and walked, or rather ran, with a quick elastic motion, to the moulds, which they filled one after another with the

sugar. Eacn man, as soon as he had exhausted his cargo by filling three or four moulds, hastened back to the 'heaters,' filled his basin again, and returned to fill other moulds. In witnessing this operation, it appeared strange that the men were not scalded by the liability of the sugar being spilled from the vessels; but practice enables them, by a peculiar spring of the body, to hasten along at a tolerably quick pace, without much personal inconvenience from the heated sugar. As it is important to have all the sugar poured into the moulds while in a certain state of temperature and granulation, a sufficient number of men is employed to 'fill-out' all the contents of one sugar-boiling in about half an hour. When the moulds are filled, and the contents still in a fluid state, the surface is stirred and scraped round the edge of the sugar, to prevent any adhesion to the mould, and also to enable the small crystals which are forming to diffuse themselves equably through the sugar.

These moulds, then, contain sugar and syrup mixed up together, in a heated and viscid state; and in the 'fill-house' they remain till the following day, in order that two effects may be produced, viz., the solidification of the sugar in the act of cooling, and the partial separation of the syrup from it. When these objects are to a certain degree effected, the moulds are taken, one by one, to a place called the 'pull-up hole,' in order to be passed to the upper floors of the building. With the usual brevity of technical language, the term 'pull-up hole' designates the mode of transfer. This hole is a vertical space, fifty or sixty feet high and four or five square, with ledges occurring at distances of every few feet in height, on which boards are placed, to serve as platforms. A door-way opens into this 'pull-up hole' at every story; and the moulds containing the sugar are handed up one by one through the hole, one man taking the moulds from the man next below him, and depositing them in some one of the upper rooms. The moulds differ greatly in size and capacity, the smallest, when filled with liquid sugar, weighing only twenty-five pounds, and the largest, for the inferior kinds of sugar, weighing as much as one hundred and fifty pounds; with the larger kinds, therefore, the weight is too great to allow the moulds to be handed up in this way, and they are hauled up by means of a rope.

While the sugar is thus being conveyed to the upper stories, we will imagine ourselves to have ascended a spiral staircase which traverses the whole height of the building, and to have entered the 'washing' and 'netting' rooms. An extraordinary area of flooring is exhibited by these rooms. We have said that most sugar refineries are lofty, and consist of a great number of stories, and we are now in a condition to see the necessity for this. Every mould full of sugar requires several days for its final completion; and thus each mould is in use so long, that a very large number is required for the purposes of the establishment, and many separate stories are necessary to contain them. In going from room to room, and from floor to floor, we saw repetitions of the same arrangements, viz., moulds ranged nearly all over the floors of the apartments, as thickly as they could stand; there could not have been less than from fifteen to twenty thousand of them filled with sugar, besides those which were waiting to be filled.

We proceed to describe the processes which the sugar undergoes in these upper rooms. A small opening being made in the apex of each mould, the mould is placed in an earthern jar, where it is left for some time. During this period, the syrup flows or drops out slowly, through the perforation, into the jar beneath. When this draining has proceeded to a certain extent, the mould is taken out of the jar, and the syrup, under the name of 'green syrup,' is emptied from each jar into one common funnel or pipe, by which it is conveyed down to the boiling-house. As this syrup still contains a portion of crystallizable sugar, it is boiled over again, with raw sugar, to produce lump sugar of a rather inferior quality, and when all the crystallizable sugar is obtained from it, the residue becomes the well-known substance *treacle*.

This draining, however, does not remove all the syrup from the sugar, a portion being still entangled among and coating the crystals; and to separate this portion, the sugar is 'washed' in rather a peculiar way. Formerly a process of 'claying' was adopted: a stratum of fine white clay diluted with water being laid on the surface of the sugar, the water percolated

through the sugar by its own weight, mixing with the syrup which yet remained in the body of the sugar, and washing it away through the orifice in the apex of the mould. By the modern improvements, this porous surface, or sponge, as it may be considered, is formed of sugar instead of clay. The rough and uneven surface of the sugar on the base of the mould is scraped off into a vessel, and there mixed with water to the state of a magma or mortar, which is again laid on the surface of the sugar. When this magma has acquired a certain degree of dryness, a clear solution of very fine sugar in water is poured on it, and allowed to remain. This solution, finding its way slowly through the mass of sugar beneath, carries with it the greater part of the syrup still remaining, together with a portion of good sugar which unavoidably accompanies it. This richer syrup, technically called 'second runnings,' is emptied from the earthern jars into a funnel which conveys it to the boiling-house, again to be boiled for the separation of the sugar from the molasses. The solution of sugar is renewed from time to time, until the syrup is so thoroughly washed away as to leave the loaf of sugar in a beautifully white state; or if the sugar be of a cheaper quality, until a corresponding degree of purity has been attained. The substitution of sugar for clay as the sponge-like layer placed in the moulds, is one of the many improvements introduced by Mr. Howard; and its importance is shown by the fact, that the process is now effected in one-fourth of the time which it used to occupy under the old system.

A medium kind of sugar, called 'clayed,' or Lisbon sugar, is much used in some foreign countries, and forms a link between moist and loaf sugar. The brown cane-juice, at a certain stage of the process, instead of being put into hogsheads, is placed in conical pots, called by the French 'formes,' with the points downwards, having a hole about half an inch in diameter at the bottom, temporarily closed with a peg. When the sugar in these pots is cool, the apex is opened, and the pots placed over jars. After this a 'claying' process is pursued, nearly similar to that alluded to above. The result of this process is, that after remaining fifteen or twenty days in the moulds, the sugar assumes a form more white and pure than that of raw sugar, but less so than refined. But it would appear probable that this old method will not be much longer pursued.

Returning to the refining processes, it will be evident that the quantity of syrup which drains from the apex of each mould is very considerable. In the first place, there is the 'green syrup,' which flows as soon as the hole in the apex is opened; and afterwards there are the finer syrups, resulting from the solution of fine sugar which is poured on the loaf or lump in the mould, and which carries off a portion of good sugar together with molasses. The subsequent boiling and preparation of those syrups, in order to obtain the crystallizable sugar from them, is almost as important an affair as the refining of the original brown sugar. A curious scale of qualities is maintained in these circumstances. The finest syrup is mixed with other sugar to obtain refined sugar of the same quality as that from which the syrup was obtained; the second quality of syrup assists in the preparation of sugar one degree lower in quality; while the coarsest, or 'green syrup,' produces a kind two degrees lower. Thus the finest syrup from the finest sugar is almost as pure as the sugar itself; while the coarsest syrup from the coarsest sugar is so thoroughly exhausted of crystallizable particles, as to be dismissed from the refining processes, and sold as treacle.

We return to the moulds. The face of the sugar in the moulds becomes rough and uneven, from the subsidence of the solid parts of the solution. When the 'washing' or 'netting' (*i.e.*, making the sugar net, neat, or pure), therefore, is completed, this face is made smooth. A man places the mould on its side across a stool, and scrapes the base or open surface of the sugar with a small instrument; a process which is called 'brushing-off,' an odd term, considering that

no brush is employed. The sugar is then allowed to remain a day or two in the mould, in order that the base may acquire hardness and firmness. A smart blow or two of the edge of the mould against a wooden post loosens the sugar within, and the loaf is turned out upon its base, after having lain in the mould for several days. We are then enabled to see the effect of the cleansing processes which the sugar has undergone; the surface is hard, crystalline, and more or less white according to the quality; the finest quality which we saw having a degree of whiteness almost rivalling that of snow. In no part of the manufacture have the modern improvements produced more decided effects than in the purity of colour now obtained. The inferior kinds of sugar retain a tint more or less dark, probably from the impossibility of expelling all the molasses from them.

The loaves or lumps (in the language of the refinery, 'loaves' are the finest quality, and 'lumps' somewhat inferior) of sugar are not, however, equally white all over when they leave the moulds, the parts near the apex being slightly damp and discoloured at the surface. To remove this damp portion, an in-

genious machine is employed. Three cutting knives or blades are ranged in a conical form, and made to rotate by the motion of a wheel; and the apex of the loaf of sugar being introduced into the cavity formed between these blades, the surface is shaved or sheared off, leaving the body of the loaf clean and smooth. Some of the larger and coarser lumps of sugar are not treated in this careful manner; but the damp apex is merely chopped off, leaving the lump as a truncated cone. The operation of shearing the surfaces of the loaves is termed 'turning off;' and the waste sugar obtained thereby, as well as that which results from the process of 'brushing off,' is melted and clarified, and converted into the fine clear solution which is poured on the sugar for the process of 'washing.'

After the loaves have been left several hours, ranged over the floors of large rooms, they are taken up one by one, wrapped in paper, and placed in an oven or stoving-room. This oven is one of the most singular parts of the building; the temperature maintained therein—about 140°—is too great to allow a stranger to remain long in it; but we saw sufficient to show the ingenuity of the arrangement. It may be characterized as a room, about ten feet by eight, and sixty feet in height, provided with tiers of shelves at intervals of every two or three feet, and having several doors, one over another, in the side, each door opening into one of the ranges or stories of 'netting' rooms. The lower part of this room or oven—for we may call it either—is occupied by a mass of steam-pipes, so extremely numerous, that the united length of the whole would probably not be less than half a mile; and the heat which the steam communicates to these pipes, radiating from their surface, raises the temperature of the air in the room, and causes a current of heated air to ascend to the top. When a large quantity of sugar is to be put into this oven at one time, the temperature is lowered by opening the doors, so as to enable the men to remain in it; they stand on platforms placed across the space at various heights, and range the loaves on the surrounding shelves.

In these ovens or stoving-rooms, of which there are three, all of great height, in different parts of the refinery, the loaves and lumps of sugar remain until they are thoroughly dried; after which they are taken out and wrapped in blue paper, in which state they may be deemed finished.

An extraordinary quantity of pipes and tubes of various sizes traverse the premises in every direction. Some convey water from the well to the reservoir on the top of the building; others re-convey it to cisterns and pans in different parts; some conduct steam from the large boilers at the east side of the premises to the 'blow-up cisterns,' to the pans, to the 'heaters,' to the ovens or stoving-rooms, and to other parts; while another series convey the sugar and syrup from vessel to vessel, in different stages of their progress.

Thus have we rapidly gone over the routine of processes by which brown sugar is refined, and presented in the state of white crystalline sugar. In considering the advantages which result from any improvements in machinery or manufacturing processes, the first consideration generally is, how far the manufacturer is benefited thereby. But it is by no means unimportant to carry our inquiries beyond this point, and see in what way the improvements influence the retail purchaser. With regard to the refining of sugar, it is found that this refining is as perfectly effected by one series of processes under the modern system, as by a double series formerly; and the effect to the public is shown thus, that whatever be the price of brown sugar (and the fluctuations in this price involve political considerations which we do not wish to discuss in this place), the price of refined sugar is now only about twenty per cent. greater, whereas in former times it amounted to forty per cent. It is supposed that a saving of nearly a million and a half sterling per annum is effected in this country by these circumstances.

We may here perhaps briefly explain the mode of reducing sugar to the state called sugar-candy. The process is not conducted at sugar-refineries, but is nearly as follows:—When the cane-juice has been clarified and boiled, it is placed in old moulds, having their lower ends stopped with linen, and crossed at intervals with strings or small twigs, to retain the sugar as it crystallizes. The moulds are then deposited in a cool place; and in proportion as the syrup cools, crystals are formed. In about nine or ten days the moulds are carried to the stove and placed in pots, and a small aperture made, through which the syrup can drop slowly. When the syrup has drained off, and the crystals of sugar-candy are become dry, the moulds are taken from the stove and broken in pieces to disengage the sugar, which adheres strongly to the sides of the moulds. By previously tinging the syrup with cochineal or some other colouring substance, the candy may be made to assume any desired hue. The arrangement of the utensils used in this process is generally somewhat as follows:—A stove is set apart, the entrance into which is on the ground-floor, as near as possible to the pans: the top is usually from ten to fourteen feet above the ground, and covered like the top or crown of an oven. Beams are fastened into the wall, at a distance of about twenty-six inches from each other, and sufficient to bear a very large weight; upon which strong planks are laid when wanted. The candy-pots are placed upon the planks, and remain there till the process is finished. The pots are usually made of thin copper, without feet, and are perforated round the lower part with numerous holes, the purpose of which is this:—a coarse white thread is drawn by a needle through a hole in one side of the pot, carried across to a similar hole in the other side, brought back again through a third hole; and so backwards and forwards till the lower part of the pot is traversed by several lines of thread; after which the holes are stopped. Each string forms a nucleus round which the candy crystallizes; an effect which used formerly to be produced by the use of small twigs.